SWEDISH CONIFEROUS FOREST PROJECT
BARRSKOGSLANDSKAPETS EKOLOGI

INTERNAL REPORT 64 1977

WEIGHT LOSS VALUES FOR ONE YEAR'S DECOMPOSITION OF DIFFERENT LITTERS AT IVANTJÄRNSHEDEN

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WEIGHT LOSS VALUES FOR ONE YEAR'S DECOMPOSITION OF DIFFERENT LITTERS AT IVANTJÄRNSHEDEN

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Abstract

Weight loss values for one year's decomposition of pine needle, bark, twig and root litter and heather and moss litter are presented for stand Ih VA (120 years old).

Weight loss values for stands Ih I (clear cut), Ih II (15 years) and Ih IV (55 years) are also presented and discussed. There were differences in needle litter decomposition among the stands and most pronounced between Ih I and Ih VA. Weight loss was considerably higher for pine root litter than for heather root litter and the weight loss increased with decreasing root diameter. The same relation also appeared to hold for pine twig litter and twigs with bark lost weight faster than those without. Decomposition of needle litter was as fast in the FH-layer as in the S-layer.

Calculations on the quantities of different litters decomposed yearly were carried out for stand Ih Va. These were mainly based on measured values for weight loss and litter stored in the ground. A budget for litter turnover was calculated.

1. Introduction

Decomposition rates among litters depend mainly on temperature and moisture which determine the rate of microbial attack and activity. These former factors are strongly influenced, e.g. by the vegetation on the actual site. A clear-cut area will thus have a different climate than the mature forest alongside it.

Physical form and chemical properties will affect the litter decomposition rate. During the course of decomposition these properties will change markedly and the weight loss rate will be affected. To draw conclusions from short-time weight loss values (viz. low weight loss values) might give dubious results. For quantitative estimates of decomposition it seems necessary to use values for at least a one-year weather-cycle.

The word "decomposition" appears to have very different interpretations among the scientists studying the process. The word decomposition in this paper means weight loss of the substrate studied.

The word humus is also used with different meanings. In this paper the word means unidentifiable litter remnants and very small identifiable litter particles remaining from decomposed litter and having a size of less than 2 mm.

The calculations carried out are based on one-year weight loss values and the simplifications/assumptions mentioned in the text. An estimate is made for the average weight-loss value in the 120-year-old pine stand (Ih VA) at Ivantjärnsheden. The litter for which decomposition values are presented in this paper make up about 75% of the litter in the L-layer and the rough calculations carried out might be regarded as representative for the total decomposition rate in the layer.

This paper is intended to be the first in a series dealing with decomposition at Ivantjärnsheden, Jädraås, Sweden. At present we are still unable to draw any conclusions about decomposition versus substrate quality and the paper has been written to fulfill present needs of data for the ongoing modelling work within the Swecon project.

2. Materials and methods

2.1 Collection of litters, storing and weighing

Needle litter was sampled at the end of October 1973 and 1974 and taken from the branches of about 15-year-old trees. The brown 4-year-old needles were about ready to fall from the trees. They were sampled in an area less than 20 x 50 m^2 and were stored at $-20^{o}C$ until the sample preparation took place.

Twigs and bark were taken from litter fall samples (sampling made by J. Flower-Ellis) and stored at $-20^{o}C$ until sample preparation took place.

Moss litter (*Dicranum* sp.) was prepared by sampling moss with both living and dead parts and cutting out a short piece (about 1.5 cm) around a death point. About half the piece was thus green to green-yellow and the other half brownish. To prevent the living part from starting to grow the moss was heated to 50°C overnight and stored at -20°C until sample preparation.

Root litter was prepared in the following way: live roots (pine and heather) were dug up and stored at -20°C before sample preparation. They were cut into 10 cm pieces, diameters were measured at the thinnest part of the roots and the roots divided into the following diameter classes: $1 \leqslant \emptyset < 2$, $2 \leqslant \emptyset < 3$, $3 \leqslant \emptyset < 5$, $5 \leqslant \emptyset < 7$ mm.

Before weighing, the litters were air-dried at room temperature to about 5-6% moisture. The biggest difference in moisture was less than ± 0.5% from the average.

2.2 Litter bags, sample preparation and start of the measurements

Litter bags were made of nylon nets with a mesh size of about 1 mm. In each litter bag an amount of about 1-2 g of litter was enclosed together with a piece of plastic tape giving the weight of the litter. The sizes of the litter-bags differed for different types of litter but were large enough to allow the litter to be properly spread out within the bag. In the L-layer the bags were secured by 10-15 cm long metal pins pushed into the ground.

The samples were placed on the 20 randomly selected test spots in the 120-year-old stand (Ih VA), in the 55-year-old stand (Ih IV), in the 15-year-old stand (Ih III) and a clear-cut area without vegetation (Ih I). The experiments were started in late October 1974, except for one set of needle litter which was started in early May of the same year.

2.3 Samplings

When collected, the samples were transported directly to the laboratory, cleaned from ingrown moss and other plants and small litter remnants that had penetrated the litter bag. The weight loss was determined by drying to constant weight at 85°C. All storage for more than one day was at -20°C.

3. Results and discussion

3.1 Some methodological aspects

Litter bags covered the moss and the lichen in the L-layer and it was expected that the contact between litter, especially needles, and moss would be less than under natural conditions. As temperature and moisture change even in the short moss profile these parameters could affect the decomposition rate. It turned out, however, that the moss started to grow through the litter bag and after about 3 months in the field the moss had grown through most of the bags. The needles were thus transported - at least to some extent - down the moss profile. The downward transport of the litter bags was slower than the transport of marked needles (Berg 1977). On the other hand, needle litter decomposition was about as fast in the FH-layer as in the L-layer and it thus seems that the low rate of transportation down the profile did not affect the rate markedly.

3.2 Weight loss from the different litters studied

3.2.1 Decomposition of needles

Samplings were carried out three or four times a year in Ih VA and on all occasions a large variance was found among the decomposition values. Comparisons of the weight loss from six samplings showed that there were no sites which specifically had a high or low decomposition but the variation among the samples in a sampling apparently was random. The time of starting the experiment (Ih VA) did not appear to be particularly important for the yearly weight loss as the weight loss after one year from needles put out in May was about the same as from those put out in October. The weight loss values presented in Table 1 show that on a yearly basis there did not appear to be any differences between the stands. It also appeared that the yearly weight loss of needle litter was the same in the L-layer as in the F-layer (position between the moss in the lowest part of the L-layer and the FH-layer) with two-year weight losses of 46% (SD = 1.2) and 44% (SD = 1.5) respectively. The observation indicated that there would not be any changes in decomposition rates between different positions in the moss profile.

3.2.2 Decomposition of twig litter

The measured weight loss of the twigs, (especially for twigs without bark) was lower than that of the other litter types (Table 2). No attempt is made here to explain this low rate.

The higher rate for twigs with bark might be explained by the higher decomposition rate of the bark (Table 2). On twigs of so small a diameter as these the bark will constitute a considerable part and the higher decomposition rate on twigs with bark could thus be due to the decomposition of the bark. There was a tendency for twigs with the small diameters to have higher weight losses (Fig. 1), cf. root litter, Fig. 2. The decomposition rate appeared to be somewhat higher in Ih VA than in Ih I as twigs in the same diameter classes had somewhat larger weight losses: 1-3 mm Ø - 11.3% (SD 0.9) and 9.4% (SD 0.9) and for 3-6 mm Ø - 9.5% (SD 0.6) and 8.1% (SD 0.6) %.

3.2.3 Decomposition of moss litter

The decomposition of moss was 18% in one year (Table 2), a rate lower than that of the pine root litter but higher than heather roots (see below). Considering the lack of lignin in the moss and its physical structure, viz. small diameter and hollow structure as compared with the root litter, the value appears a bit low. A possible explanation might be the presence of inhibiting substances.

3.2.4 Decomposition of bark litter

The decomposition of bark litter was about 11% in one year (Table 2). The bark pieces were rather large (little surface vs volume) compared with e.g. needle litter, and had thus a relatively smaller surface for attack. The relatively large weight loss obtained might thus indicate easily decomposabel substrate and/or lack of inhibiting substances.

3.2.5 Decomposition of root litter

The fresh root litter used in the study could be expected to be a dubious substrate. It appeared, however, that naturally formed litter was extremely inhomogenous viz. in very different stages of decomposition. It would be difficult to carry out meaningful studies with such a structure.

There appeared to be a marked difference between heather root litter and pine root litter weight loss rates, with about a 3-5 times higher rate for pine root litter (Fig. 2). This fact could be due to inhibitors for microbial growth being present in the heather roots. Another rate-limiting factor appeared to be the root diameter, with the highest decomposition rates for the smallest diameters (Fig. 2). The deviation values were relatively high but the diameter classes had, on the other hand, rather large intervals and the roots were very irregular in shape, both of which could partly explain the variation.

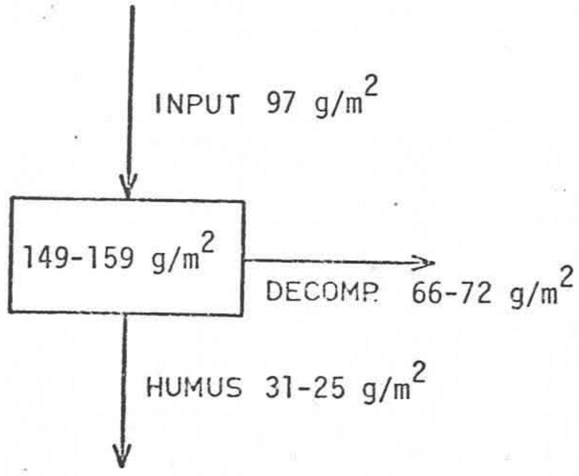
3.3 Calculations of litter biomass budgets for some litter types in the L-layer

These budgets were calculated from the yearly litter input for the litters, the amount of litter stored on the ground and the decomposition rate. The amount of humus formed was thus the difference between input and decomposed amounts. An attempt was made to estimate the total weight loss rate for litter and humus in the L-layer. On the basis of one-year weight loss values it has been necessary to assume a constant weight loss rate for each litter type regardless of changed substrate quality. The assumption was made that there is steady state in this stand so that the amount of litter stored in the ground was constant as calculated on a yearly basis.

3.3.1 Needle litter

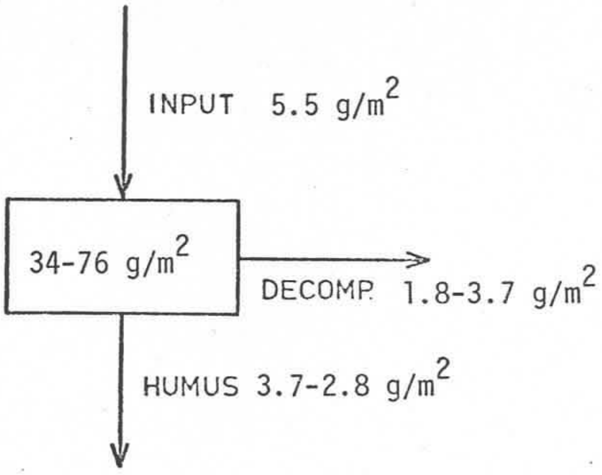
The yearly input of needle litter to the L-layer is about 97 g/m^2 (Flower-Ellis, pers. comm.) and the amount stored in the layer about 149-159 g/m^2 (Staaf & Berg 1977). The yearly weight loss of new-fallen needle litter was 27-28% (Table 1) which thus meant a weight loss of 40-45 g/m^2/yr from the litter in the layer and 26-27 g/m^2 from the litter falling in October, making 66-72 g/m^2 weight loss from the needle litter yearly. The assumption of a constant weight loss rate might hold for needle litter for at least the first three years of decomposition (Berg, in manuscr.).

In the figure presented below the weight loss for the year was calculated from the input value and the minimum value for the stored litter. This would give 25-31 g/m^2/yr of needle litter transformed into humus.



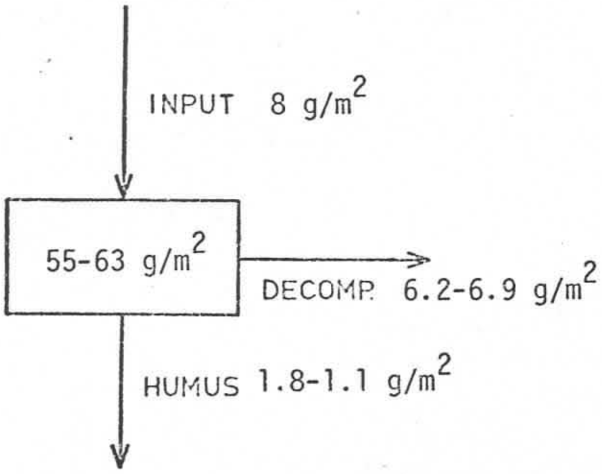
3.3.2 Twig litter

The amount of twig litter in the L-layer has been found, so far, to vary between 34 and 76 g/m^2, and contains mainly twigs without bark with diameters of 1-10 mm, of which 25-53 g are of less than 5 mm diameter and 9-23 g are of more than 5 mm diameter (Staaf & Berg 1977). The yearly input varies slightly, with 5.5 g/m^2/yr as a reasonable average value (Flower-Ellis, pers. comm.). The yeraly weight loss value of 4.5% (Table 2) was taken as a mean value for twig litter. Assuming a constant decomposition rate we would get a total yearly weight loss of 1.8-3.7 g/m^2 from the twigs. This figure, which might be low, would give an amount of 3.7-2.8 g/m^2 of humus yearly.



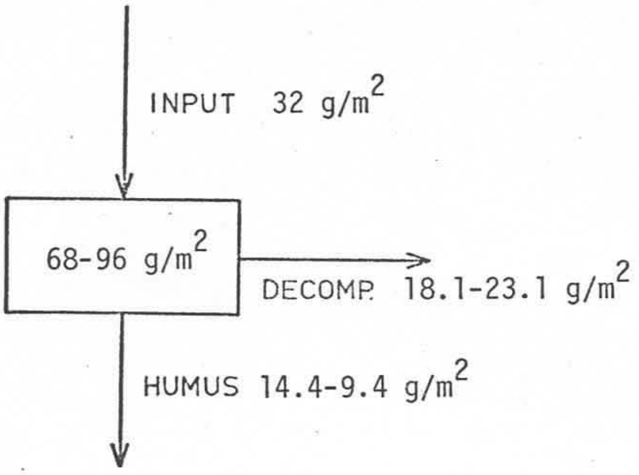
3.3.3 Bark litter

The yearly input of bark litter is about 8 g/m^2 (Flower-Ellis, pers. comm.) with the amount of bark in the L-layer varying about 55-63 g/m^2 (Staaf & Berg 1977). The yearly weight loss of 11% resulted in 6.2-6.9 g/m^2/yr of decomposition and thus we would get 1.8-1.1 g/m^2 of humus from the bark litter.



3.3.4 Moss litter

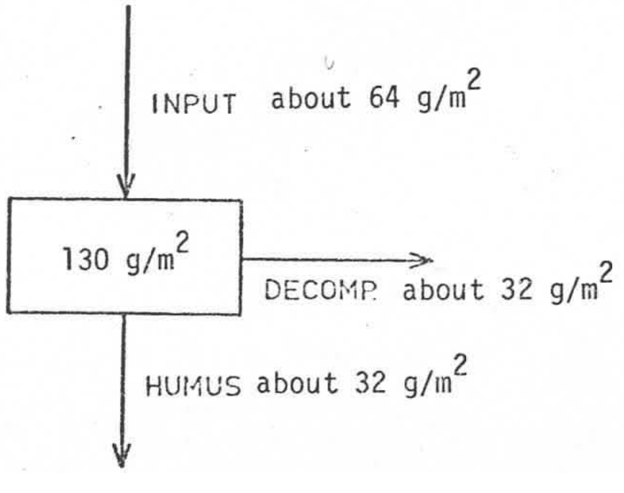
The amount of moss litter in the L-layer was found to be about 68-96 g/m^2 (Staaf & Berg, in manuscript). The average yearly litter input might be about 32.5 g/m^2 (Stjernkvist, pers. comm.). The decomposition was 18% per year (Table 2) which would give a weight loss of 18.1-23.1 g/m^2/yr. Thus we obtained 14.4-9.4 g/m^2 as humus.



3.3.5 Remaining fractions

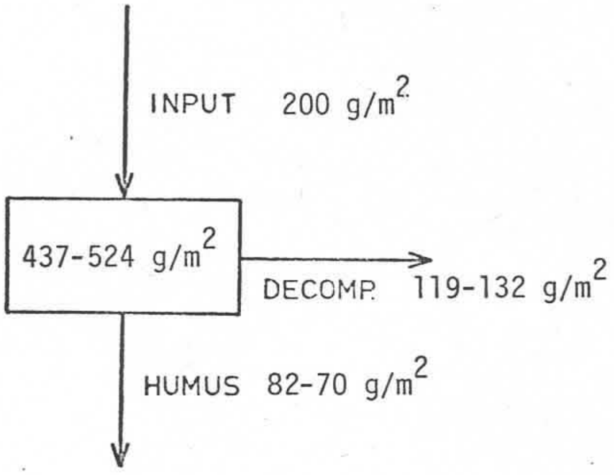
The litter fractions for which the weight loss has still to be determined are: *Calluna* aboveground litter with an input of about 16 g/m^2/yr (Persson, pers. comm.) and an amount of litter in the L-layer of 55 g/m^2 (Staaf & Berg 1977); *Vaccinum* leaves with an input of about 7.5 g/m^2/yr (Persson, pers. comm.) and litter in the L-layer of about 30 g/m^2 (Staaf & Berg 1977). The input from pine cones is estimated to be about 40 g/m^2 (Albrektsson, pers. comm.) and the stored amount about 45 g/m^2 (Staaf & Berg 1977). These litter fractions made up as much as 18% of the stored L-layer litter and en estimated weight loss value could be useful for the calculations.

If we assume that an amount corresponding to about half of the yearly input was decomposed, this would five 25% decomposition viz. 32 g/m^2/yr and a humus formation of 32 g/m^2/yr.



3.3.6 Summation of the calculation for L-layer litters

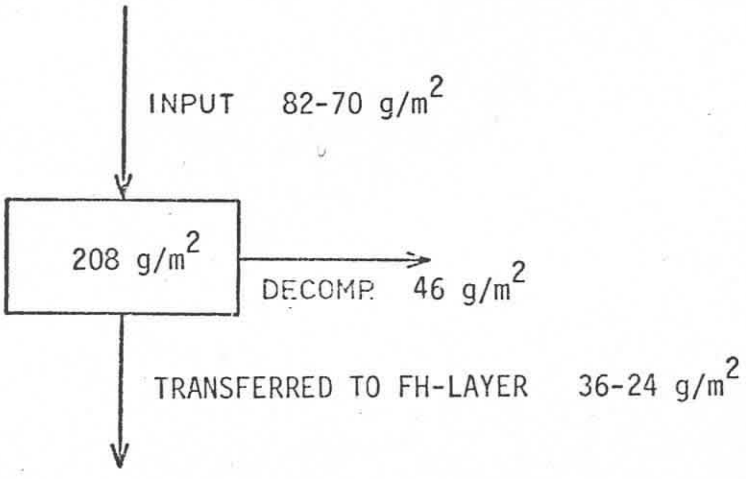
From the calculations above we obtain a weighed decomposition value for the L-layer litters that would be 27-25% of the stored litter and 119-132 g/m^2/yr. The humus formation would be about 82-70 g/m^2/yr.



3.3.7 The humus fraction

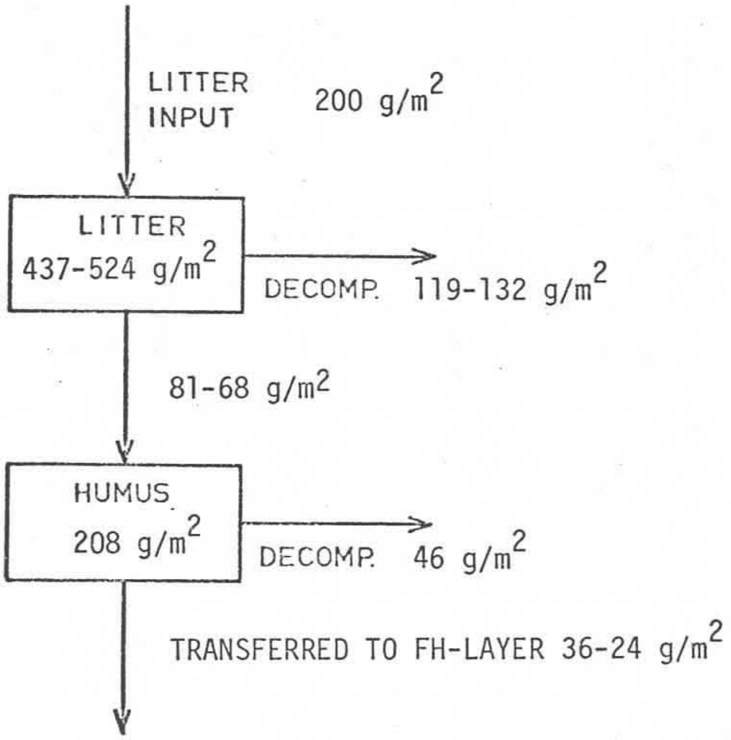
The humus fraction sampled in the L-layer was determined to be about 208 g/m^2 (Staaf & Berg 1977). Of the total amount of litter and humus this fraction made up about 35% and thus ought to be of importance in a budget calculation. The input to the humus fraction - as calculated in section 3.3.1-3.3.6 was about 82-70 g/m^2/yr. Measurement of the decomposition rate for humus is probably not possible and thus an estimate was made. So far it appears reasonable to use the yearly weight loss value (22%) for needles in an advanced state of decomposition with weight loss 40%. Since the dominating litter fraction was needle litter it could be expected that a correspondingly large part of the humus fraction came from the needle litter.

The yearly decomposition would thus be 46 g/m^2 and with an input of 82-70 g/m^2 we would get 36-74 g per m^2 transferred to the FH-layer.



3.3.8 Overall calculation for the L-layer

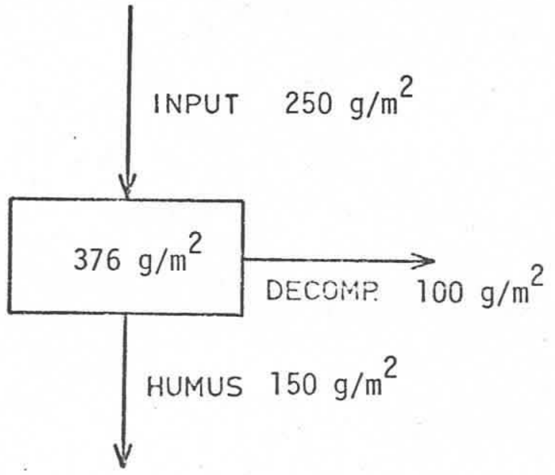
The total yearly litter input is about 200 g/m^2/yr and with the 427-524 g/m^2 stored we get 119-132 g of weight loss per year. The formation of humus would be 82-70 g/m^2 and its decomposition 46 g/m^2. The formation of remnants should be 36-24 g/m^2.



3.4 Calculation of litter biomass budgets for root litter in the FH-layer

For this calculation rough values were used and assumptions were made with the aim of calculating a rough value for the decomposition. The root litter stored in the FH-layer was determined in Ih VA and was found to be; pine root litter 125 g/m^2, cowberry root litter 48 g/m^2 and heather root litter 203 g/m^2 (Persson, pers. comm.). The root litter input value is taken from the 15-year-old stand (Ih II) and is certainly too high. Pine root litter had a yearly input of roughly 120 g/m^2, cowberry root litter 100 g/m^2 and heather root litter about 30 g/m^2 (Persson, pers. comm.).

About 27% of the pine root litter (>2 mm) decomposed annually and this value is also assumed to hold for cowberry root litter, which would thus give a yearly weight loss of 81 g/m^2. The value of about 9% for heather root litter gives 19 g/m^2/yr. We thus get a decomposition of 100 g/m^2 and a humus formation of 150 g/m^2.



The present paper is a first attempt to calculate the decomposition of litter and humus. A second paper with calculations on carbon and nitrogen will follow when more information is available.

4. Literature

BERG, B. 1977. Transport of pine needles through moss communities of the S-layer in a 120-year-old stand of *Pinus silvestris* (Ih VA). Swed. Conif. For. Proj. Int. Rep. 63.

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VAN CLEVE, K. 1974. Organic matter quality in relation to decomposition. In: Soil organisms and decomposition in tundra. Ed. A.I. Holding, O.W. Heal, S.F. MacLean Jr & P.W. Flanagan. Publ. by the International Biological Programme, Tundra Biome Steering Committee. Stockholm 1974.

Table 1. Weight loss (w.l.) values (%) for pine needles in pine stands of different ages (741028-751028). Standard error (SE) within parentheses.

Layer		Stand				
		Ih I	Ih III	Ih IV	Ih VA	
L-layer	1 year w.l.	25.8(0.9)	25.8(0.6)	27.0(0.5)	28.2(0.6)	27.3*(1.1)
	2 year w.l.					45.8 (5.4)
FH-layer	2 year w.l.					44.3 (6.7)

* 740505-750505

Table 2. Weight loss values for some different litters in Ih VA. Per cent weight loss for one year, SE within parentheses.

	Twigs		Bark	Moss
	with bark	without bark		
1-3 mm Ø	11.3 (0.9)		11.2 (1.3)	18.2 (1.1)
3-6 mm Ø	9.5 (0.6)	4.5 (0.4)		
6-9 mm Ø	7.0 (0.9)	4.6 (0.9)		

Table 3. Weight loss in % for root litter of different diameters after decomposition for one year. SE in parentheses

Diameter	Pine root litter	Heather root litter
1-2 mm	27.0 (1.3)	9.0 (1.2)
2-3 mm	27.2 (1.2)	5.3 (0.7)
3-5 mm	22.3 (1.3)	5.0 (0.4)
5-6 mm	14.8 (0.6)	

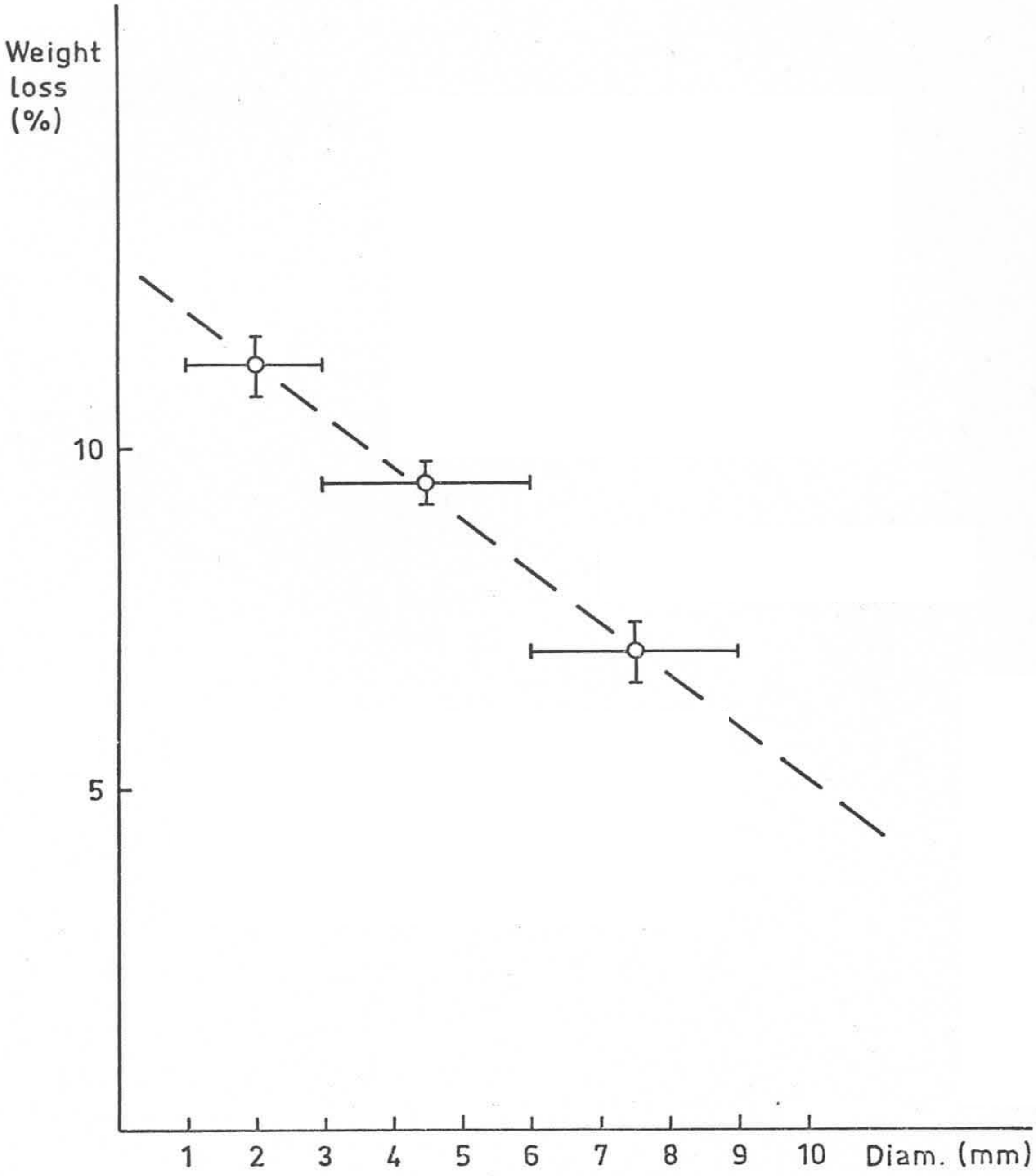

Figure 1. Decomposition in one year of pine twigs with bark. The diameter class sizes are indicated. Standard error indicated.

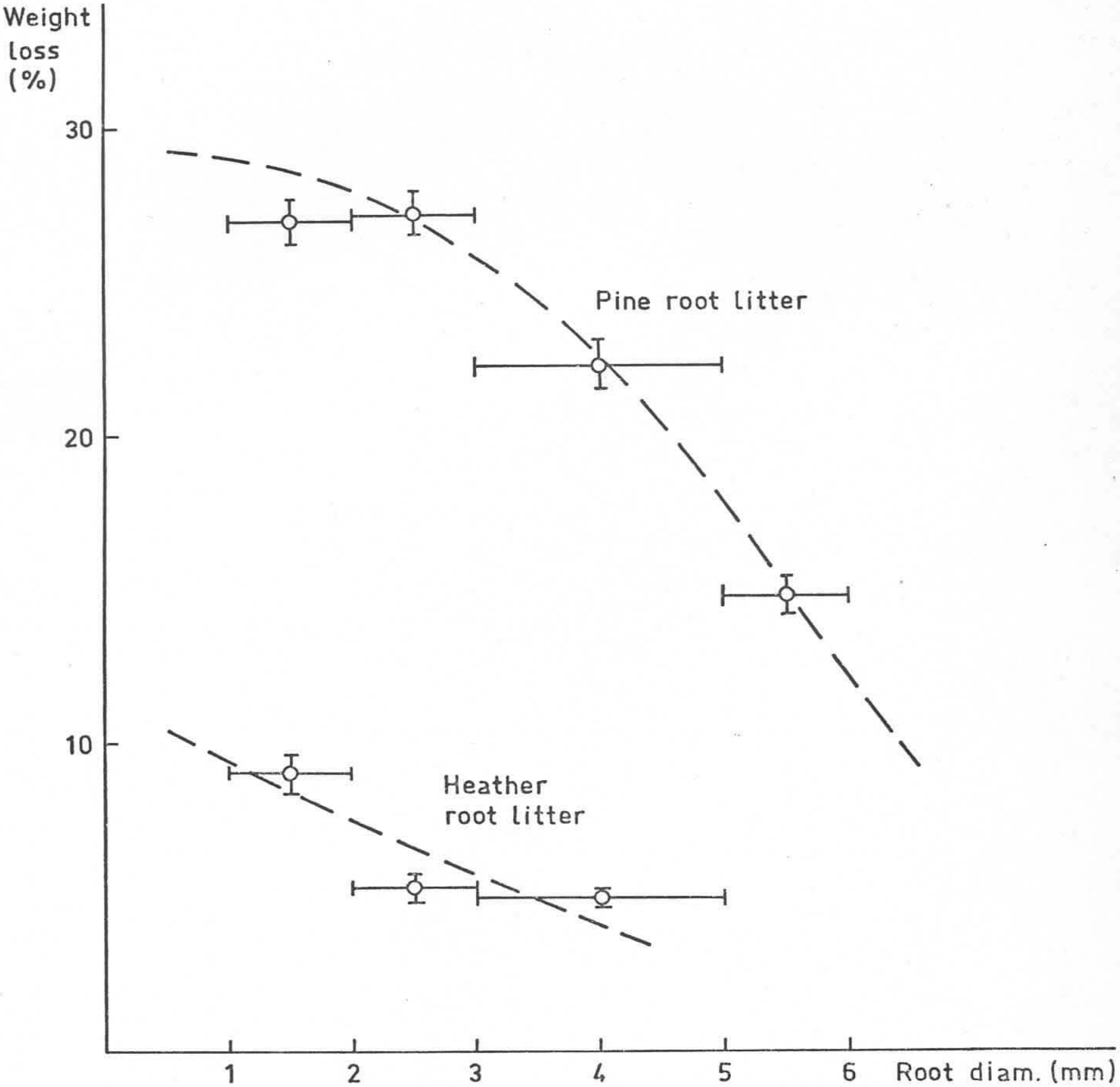

Figure 2. Decomposition in one year of heather root litter and pine root litter of the diameter classes indicated. Standard error indicated.